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Current Opinion

Surgical Technology and its Impact on Practice

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Introduction

Modern developments in surgical technology have unfolded at an exponential rate over the last two decades. Investment by manufacturers of specialized equipment and computer technologies aimed at the surgical market has been considerable. This has been fuelled by a rapid development in minimal access surgical techniques that is partly in response to increased consumer awareness of potential treatment options. Increased affability of the surgeons and improved information technology, in particular the widespread use of the internet, has led patients to present to the surgeon of their choice with details of the operative technique they wish performed. The increased costs associated with advancing surgical technologies are said to be offset by a combination of increased patient safety, increased cosmesis, shorter hospital stay and a faster return to normal activities. However, these rapid developments have led to changes in surgical training as a result of the need for further skills acquisition in an environment where surgical technologies are reducing the indications for traditional surgical intervention.

While it is not possible to provide a list of all available surgical technologies and their applications, we hope to provide a flavour of modern surgical practice by referring to selected technologies. This rapid expansion in modern surgical technologies started with improvements in diathermy technology combined with the explosion in minimal access techniques in the early 1990s. The last years of the twentieth century saw the laparoscopic concept further developed to enable "telesurgery" to become a reality, leaving us to consider what the twenty-first century may bring.

Minimal access surgery

Minimal access surgical procedures allow surgeons to reduce patient morbidity while maintaining quality of care. Laparoscopy involving an optical telescope in the operator's hand while operating with the remaining hand was revolutionized with the development of miniature video camera systems that allow the surgical field to be viewed on a monitor. This meant that the assistant could hold the camera as well as retract adjacent viscera, allowing the surgeon to operate with both hands. The use of laparoscopic techniques rapidly spread to encompass many operations in many surgical specialties. This rapid expansion was aided by the emergence of a variety of new equipment and technologies, such as disposable trocars, clip applicators and laparoscopic stapling devices. However, caution is encouraged by some to ensure that the introduction of novel technologies does not change the nature or outcome of the intended procedure. During laparoscopic cholecystectomy, some authors advocate the routine use of intraoperative cholangiography, as was standard with open cholecystectomy.[1] Most surgeons, in contrast, rely on the availability of other novel technologies to avoid intraoperative cholangiograms during cholecystectomy, such as endoscopic retrograde cholangiopancreatography (ERCP) and magnetic resonance (MR) cholangiopancreatography. This is particularly relevant with the wide range of interventional equipment designed for use during ERCP, such as biopsy catheters and cytology brushes, as well as balloons, baskets and contact lithotripsy technology for calculi extraction. Of course, the technology used in laparoscopy is also widely practised in thoracoscopic and arthroscopic surgery as well as endoscopic neck surgery.

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Image-guided surgery represents a novel concept in surgical access. In recent years, fluoroscopy, ultrasound (including three-dimensional, 3D, ultrasound), computed tomography and MR imaging have provided surgeons and interventional radiologists with the ability to guide catheters and instruments into various body cavities and spaces to provide drainage or perform biopsies. These procedures are usually performed under local anaesthesia or sedation. Our unit, among others, has gained considerable experience with the use of an interventional MR (iMR) scanner (Figure 1) to allow image-guided surgery under general anaesthetic for anal fistulae, excision of breast lesions and resection of soft-tissue sarcomas.[2] In addition, we have gained considerable experience with the use of iMR to achieve guided laser thermal ablation of primary and secondary liver tumours, renal tumours and symptomatic uterine fibroids.[3] This technique also allows dynamic imaging that facilitates such diagnostic procedures as MR defaecating proctography.[4]

Figure 1. Interventional magnetic resonance imaging scanner.

Transanal endoscopic microsurgery (TEMS) is a minimally invasive surgical technique for performing local excision of rectal lesions in the mid and upper rectum that would otherwise be inaccessible for local excision by the direct transanal approach (Figures 2 and 3).[5] TEMS combines a low complication rate and high patient comfort, and has low recurrence rates and excellent survival after radical surgery for benign lesions and early cancers. In the absence of this technology, a low anterior resection or abdominoperineal resection with permanent stoma would be required. Our series revealed a mean hospital stay of 3 days with a histologically clear margin in 98% of cases.[5]

Figure 2. Transanal endoscopic microsurgery setup.

Phacoemulsification of cataracts under topical anaesthesia,[6] with a foldable intraocular lens inserted through a 2 mm incision, represents a further example of technology providing a novel minimally invasive technique for a common problem. This advance is of great benefit to the elderly.

Lymphatic mapping and sentinel lymph node biopsy have been rapidly assimilated into clinical oncology. Open surgery in conjunction with a blue dye and a radioisotope tracer is used to identify the first, or sentinel, node in the lymphatic drainage field from a tumour site. This technique can be used in all solid tumours and is current practice for melanomas and breast cancers.[7] The rapid acceptance of this technique in clinical practice is the result of multiple factors, including accuracy, decreased morbidity, and a more focused and sensitive pathological evaluation.

The evolution of intraluminal vascular stenting[8] has had a profound effect on the management of both thoracic and abdominal aortic aneurysms and carotid and renal artery stenosis. This technique provides a minimally invasive alternative to what was previously major vascular surgery with high morbidity and mortality in a high-risk group, and has had a huge impact on hospital stay and patient outcome.

The paradox of minimal access surgery is that as technological advances proceed at an alarming pace, procedures that have only recently become minimally invasive are already under threat from new technologies. Recently developed endoscopic antireflux procedures, including endoscopic suturing devices, focal radiofrequency coagulation in the cardia and bioimplants, are currently under evaluation.[9] These techniques are generally performed with minimal sedation as day cases,

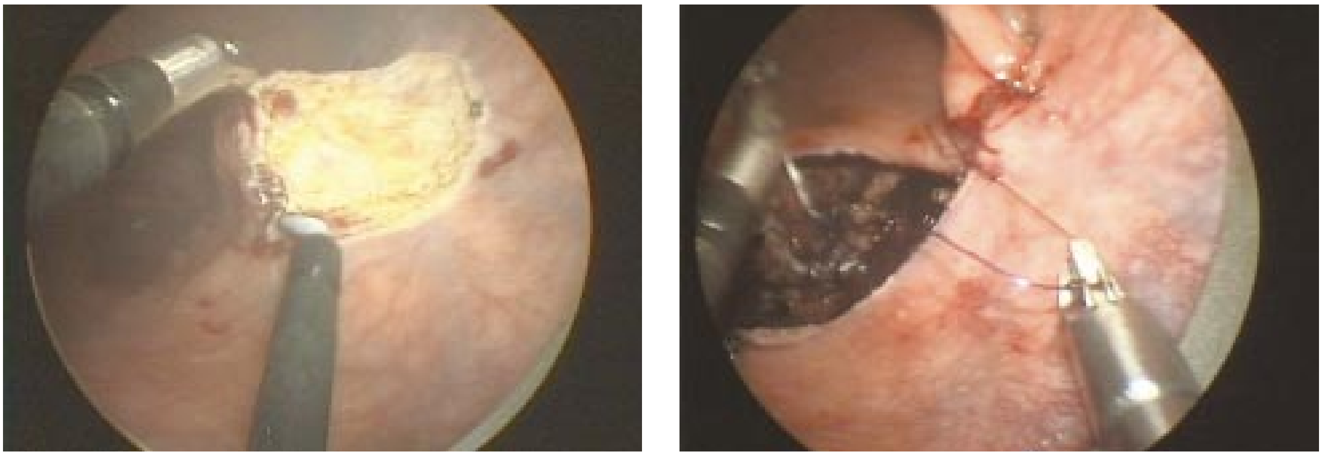

Figure 3. Transanal endoscopic microsurgery – endoscopic view.

and may provide a suitable alternative to laparoscopic antireflux surgery.

Robotics in surgery

The term “robotic” surgery is a misnomer, as the robot acts under guidance from a surgeon seated at a remote console (Figures 4 and 5). Surgical telemanipulator systems have the advantage of restoring stereoscopic (3D) vision and hand–eye coordination, which is lost with traditional laparoscopic surgery. The robotic arms allow up to seven degrees of freedom of motion, mimicking the human wrist. Computer-enhanced tremor ablation and motion scaling allow for improved technical dexterity. Currently, this system is used for antireflux procedures, Heller’s cardiomyotomy, abdominoperineal resection, rectopexy, prostatectomy, and off-pump coronary artery bypass graft surgery.[10]

An interesting progression of surgical robotics involves the use of remote telerobotics, wherein telecommunication technology is used to transfer data from the operating surgeon at a robotic console to the "master slave manipulator", the robotic arms, in a different location.[11] Using such technology, a robotic-assisted cholecystectomy was performed on a patient in Strasbourg, with the surgeon controlling the robot from New York. Despite the distance, the mean lag time using a high-speed terrestrial network was 155 ms. This technology may be able to ensure the availability of surgical expertise in remote locations and may enhance surgical training.

Coagulation and dissection

Many of the recent developments outlined above have been aided by advances in the technology associated with diathermy, the traditional tool to aid dissection while achieving haemostasis. The harmonic scalpel[12] (UltraCision®, operating frequency 55 kHz; Ethicon Endo-Surgery, Norderstedt, Germany) employs a titanium knife blade driven by a high-power ultrasound transducer oscillating longitudinally with a displacement amplitude of 10 to 50 µm. At the interface between blade

Figure 4. DaVinci robot: operating console.

Figure 5. DaVinci robotic arms.

and tissue, high temperatures and cavitation occur, and coagulation of the tissue provides closing of vascular structures in addition to cutting. Similarly, the LigaSure® vessel-sealing system[13] (Valleylab, Boulder, CO, USA), consisting of a bipolar radiofrequency generator available for both open and laparoscopic surgery, is in use for both vessel and cystic duct sealing. These dissection devices are said to offer less perfusion of heat away from the surgical field, reducing damage to adjacent organs.

Conclusions

Modern surgical technology is being developed at an alarming rate. The technologies described above represent only examples of what is currently being used in practice, as a full list from all surgical specialties would be exhaustive. Effectively, these technologies allow us to improve the quality of surgical care for our patients while reducing morbidity, mortality and hospital stay in most instances. However, this is at increased cost to health care providers, along with implications for surgical training, as new surgical skills need to be developed at a similar pace to the technology.

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